DATA-INTENSIVE RESEARCH IN ECOLOGY: COMBINING LARGE DATASETS, BEST PRACTICES, AND COMPUTATIONAL TRAINING

Kristina Riemer
University of Florida

The start of my computing journey

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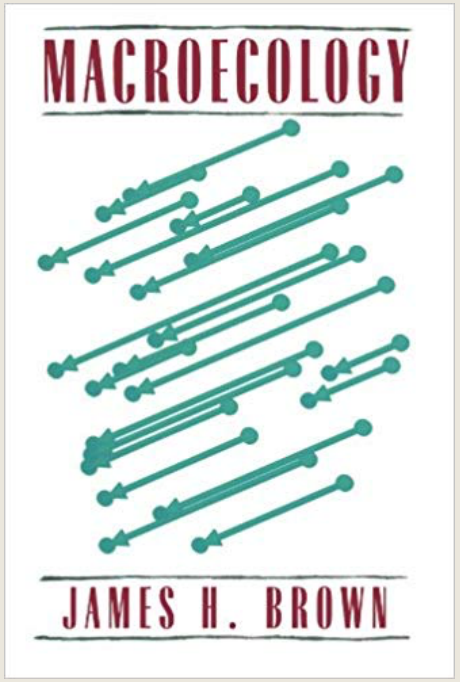


What determines organism size?

Opinion

Cell PRESS

Declining body size: a third universal response to warming?

Janet L. Gardner[1], Anne Peters[2,3], Michael R. Kearney[4], Leo Joseph[5] and Robert Heinsohn[1]

[1] Fenner School of Environment and Society, Australian National University, Canberra, ACT 0200, Australia
[2] Behavioral Ecology of Sexual Signals Group, Max Planck Institute for Ornithology, Vogelwarte Radolfzell, 78315 Radolfzell, Germany
[3] School of Biological Sciences, Monash University, VIC 3168, Australia
[4] Department of Zoology, The University of Melbourne, VIC 3010, Australia
[5] Australian National Wildlife Collection, CSIRO Ecosystem Sciences, GPO Box 284, Canberra, ACT 2601, Australia

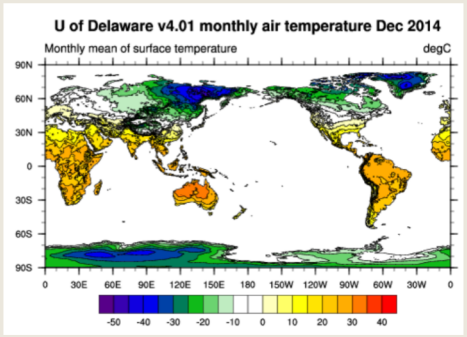
- Smaller when warmer
- One of few ”rules” in ecology
- Datasets with small sample sizes

Data-intensive approach to size response to temperature

15 million museum records

Data-intensive approach to size response to temperature

VerNet

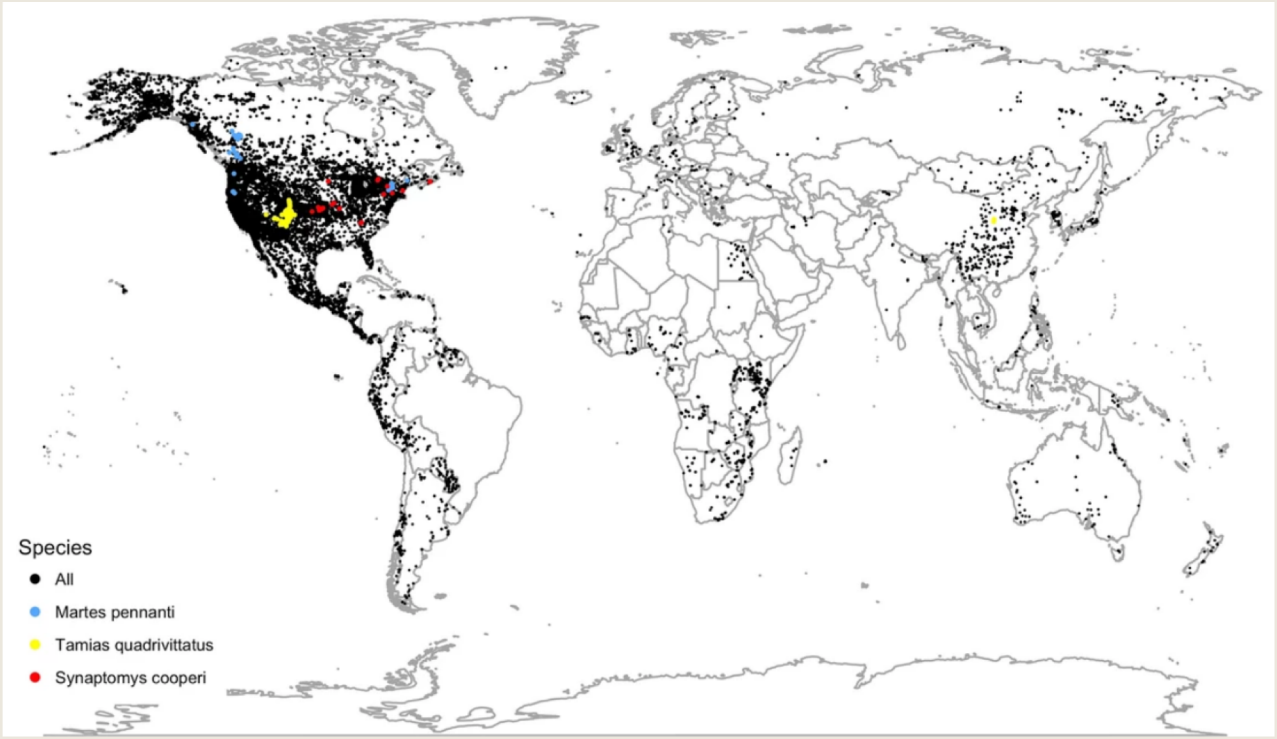


15 million museum records

+

Raster of >250,000 grids

Data-intensive approach to size response to temperature

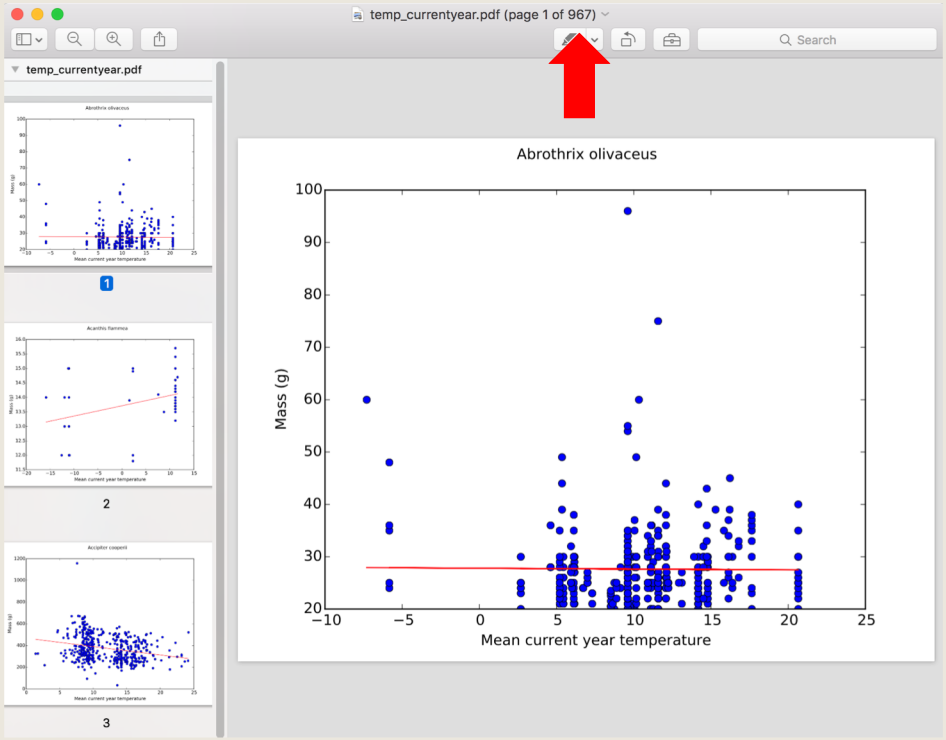


New challenges required new skills

```
#-------FUNCTIONS---------
download_VN = function(raw_file_path){
  # Download organismal data (Vertnet)
  #
  # Args:
  #   raw_file_path: file path to raw data
  #
  # Returns:
  #   Single csv of four desired class-level datasets with only necessary columns
  #   and only rows with mass values
  if(!file.exists(raw_file_path)){
    rdataretriever::install("vertnet-amphibians", "sqlite", db_file = "data/all_vertnet.db")
    rdataretriever::install("vertnet-birds", "sqlite", db_file = "data/all_vertnet.db")
    rdataretriever::install("vertnet-mammals", "sqlite", db_file = "data/all_vertnet.db")
    rdataretriever::install("vertnet-reptiles", "sqlite", db_file = "data/all_vertnet.db")
    database = src_sqlite("data/all_vertnet.db")
    amphibians_query = "SELECT scientificname, class, ordered, family, year, decimallongitude
    birds_query = "SELECT scientificname, class, ordered, family, year, decimallongitude, dec
    mammals_query = "SELECT scientificname, class, ordered, family, year, decimallongitude, d
    reptiles_query = "SELECT scientificname, class, ordered, family, year, decimallongitude,
    query = paste(amphibians_query, "UNION ALL", birds_query, "UNION ALL", mammals_query, "UN
    subset_data = tbl(database, sql(query))
    write.csv(subset_data, file = raw_file_path)
  }
}
```

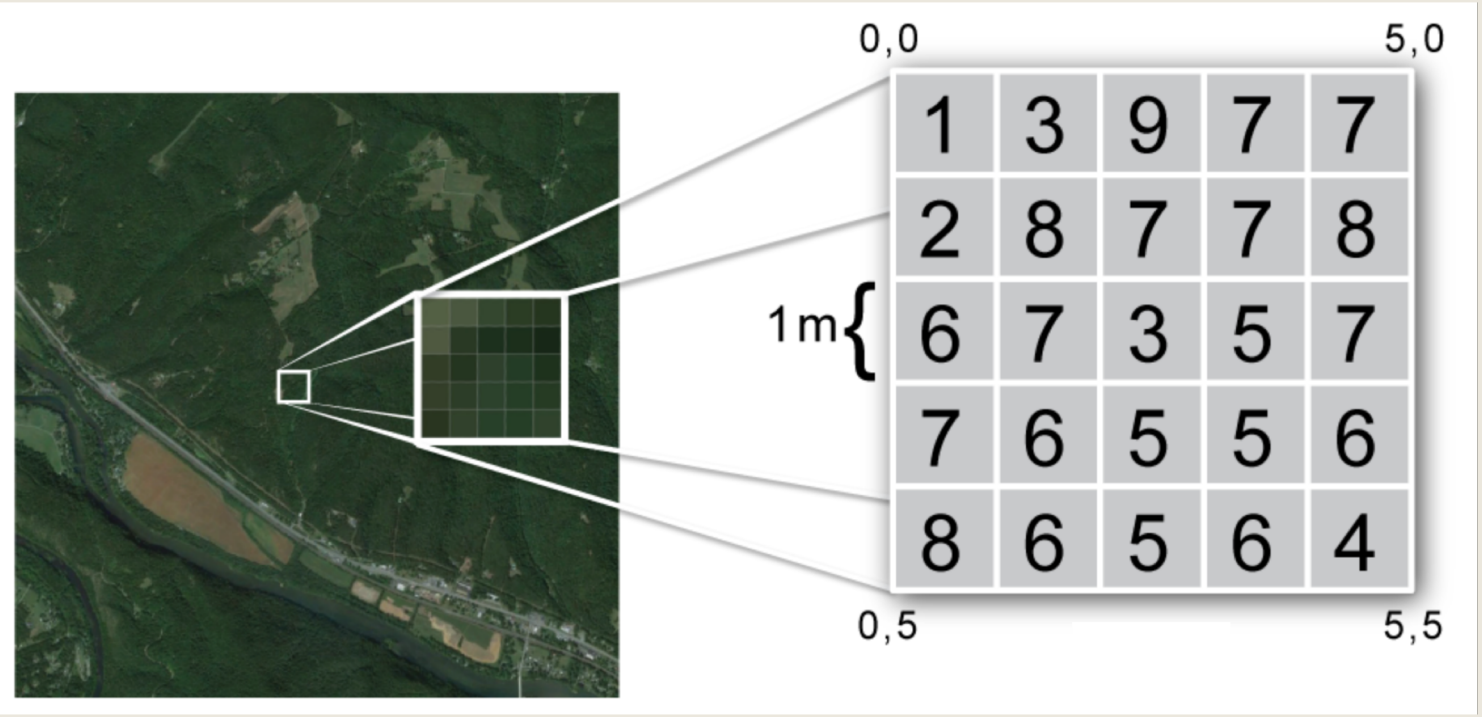
1. Very large amounts of data

New challenges required new skills



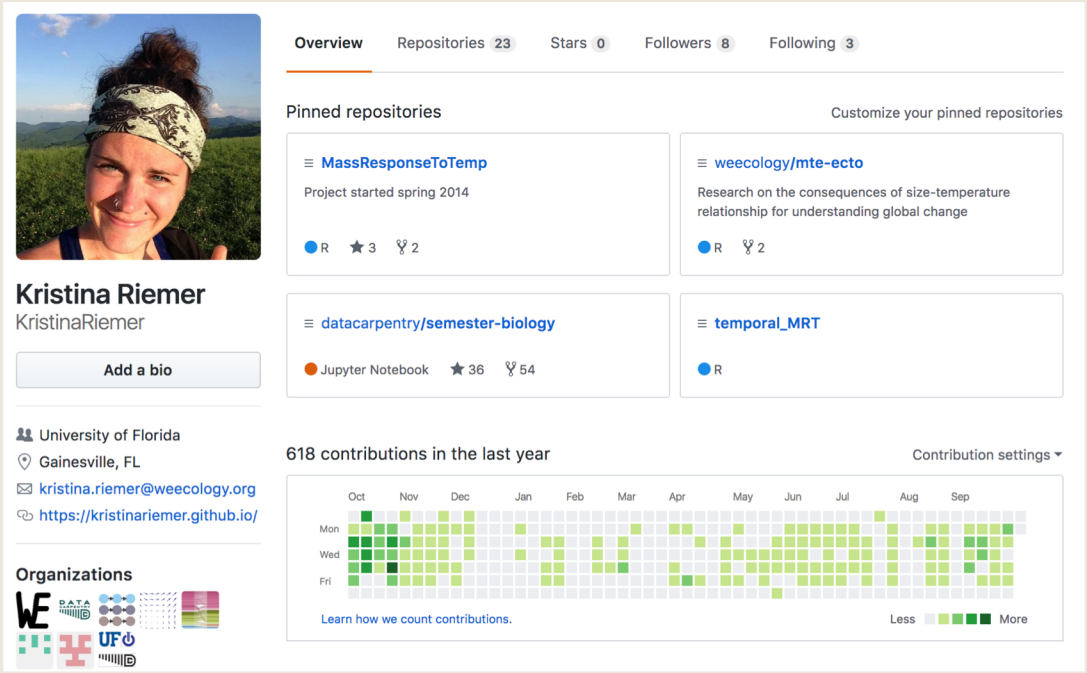
2. Repeated tasks on lots of data

New challenges required new skills



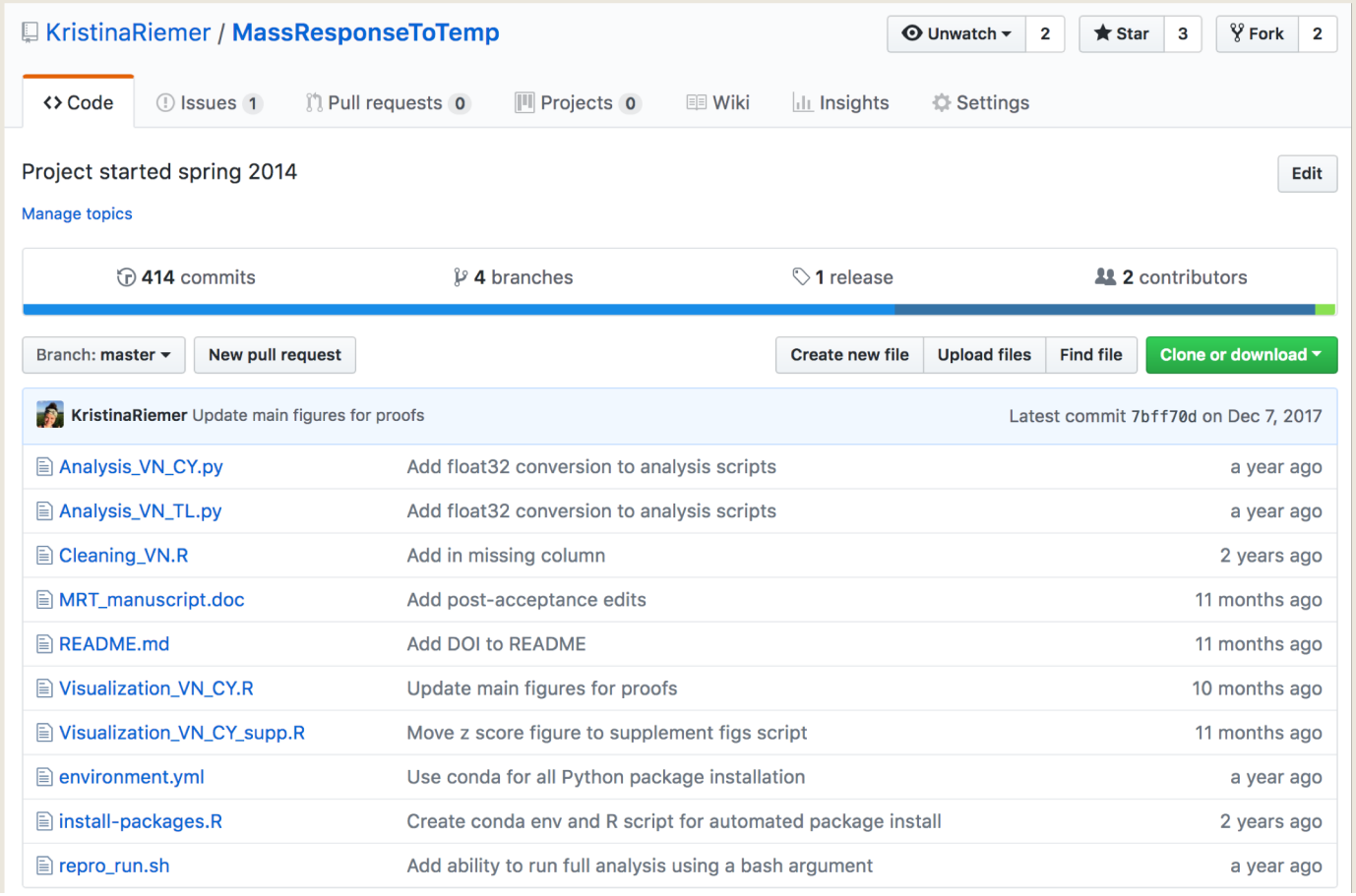
3. Spatial data

New challenges required new skills



4. Tracking code

Success!



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Analysis_VN_CY.py	Add float32 conversion to analysis scripts	a year ago
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Cleaning_VN.R	Add in missing column	2 years ago
MRT_manuscript.doc	Add post-acceptance edits	11 months ago
README.md	Add DOI to README	11 months ago
Visualization_VN_CY.R	Update main figures for proofs	10 months ago
Visualization_VN_CY_supp.R	Move z score figure to supplement figs script	11 months ago
environment.yml	Use conda for all Python package installation	a year ago
install-packages.R	Create conda env and R script for automated package install	2 years ago
repro_run.sh	Add ability to run full analysis using a bash argument	a year ago

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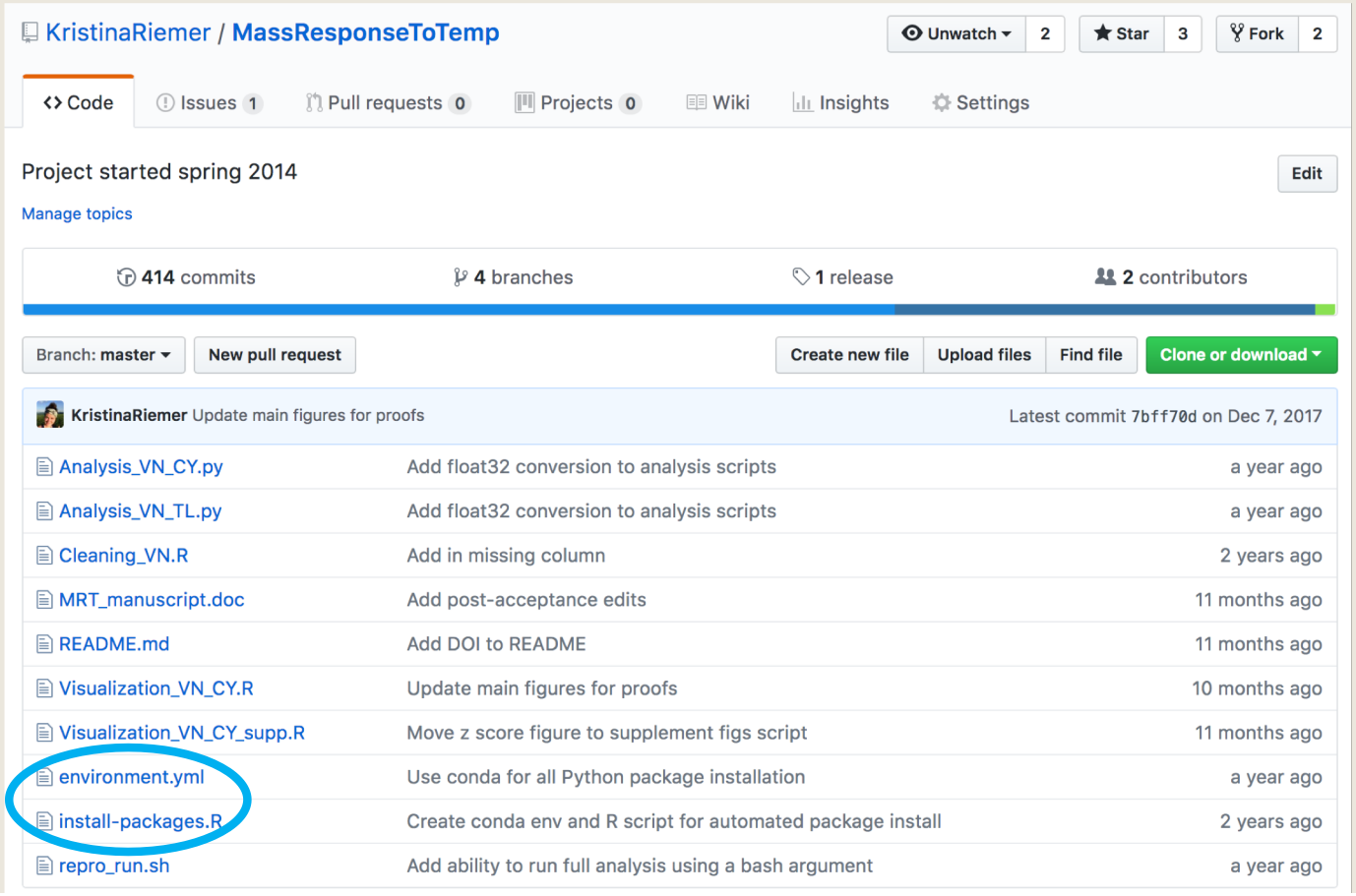
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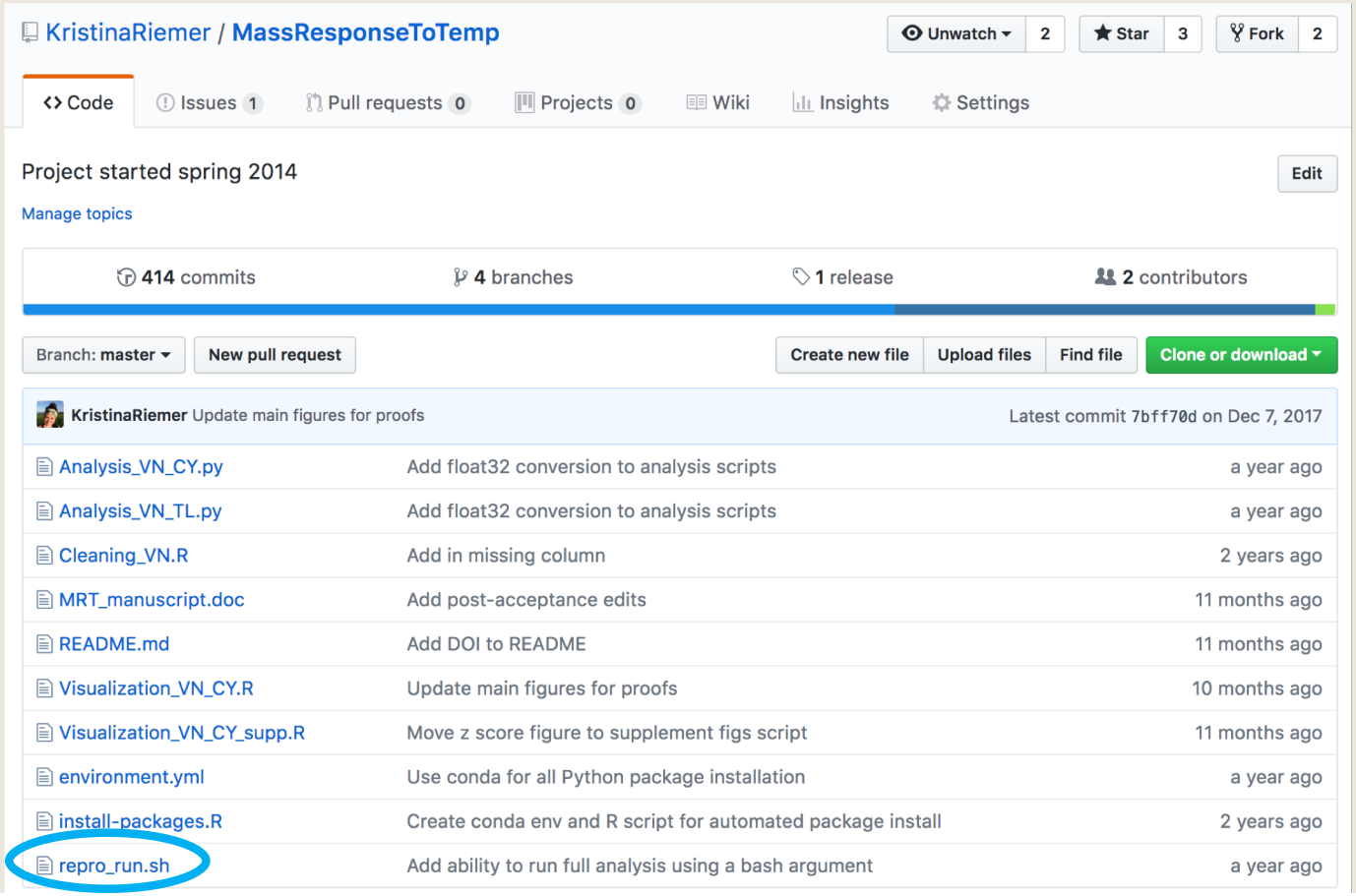
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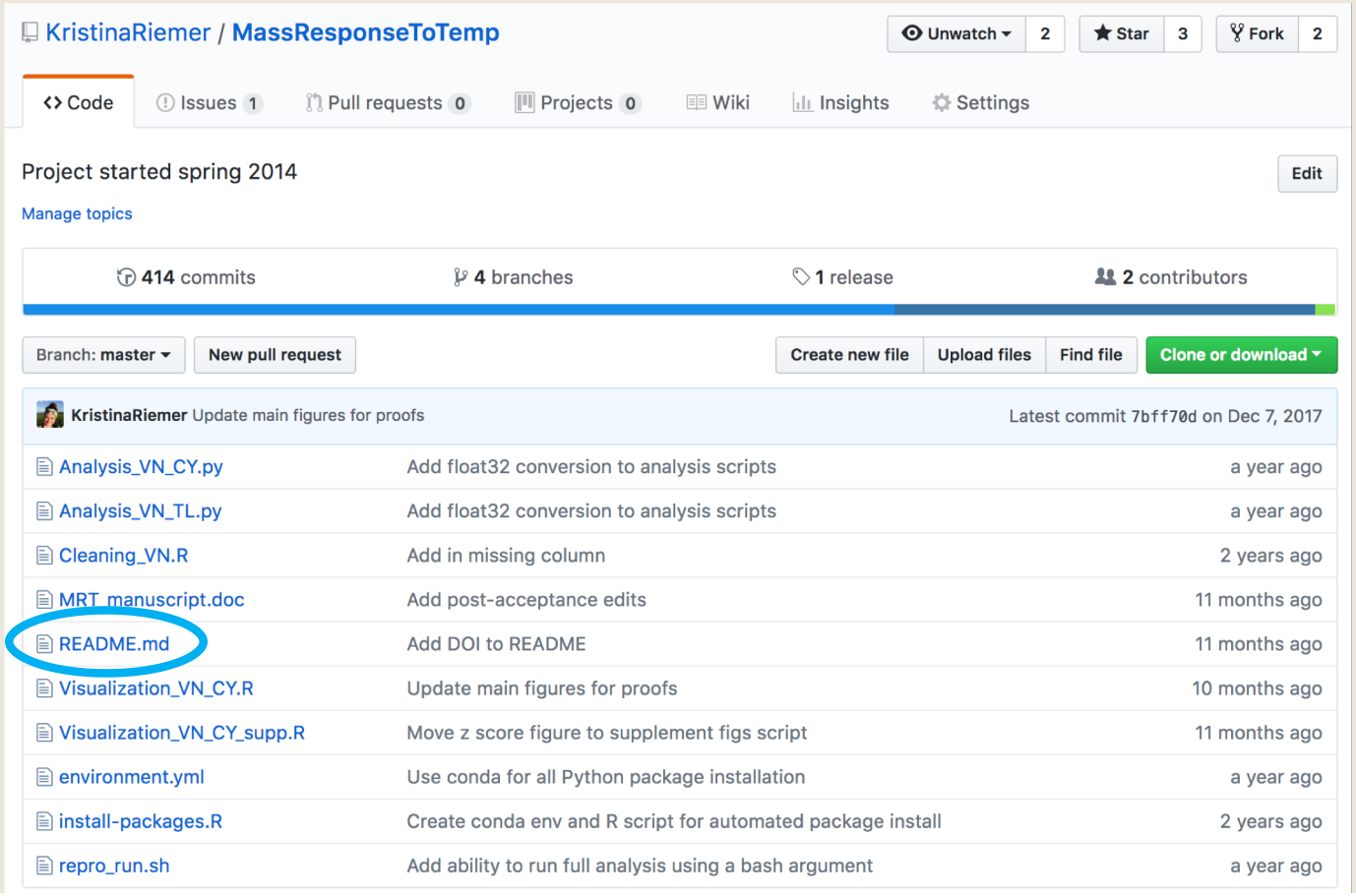
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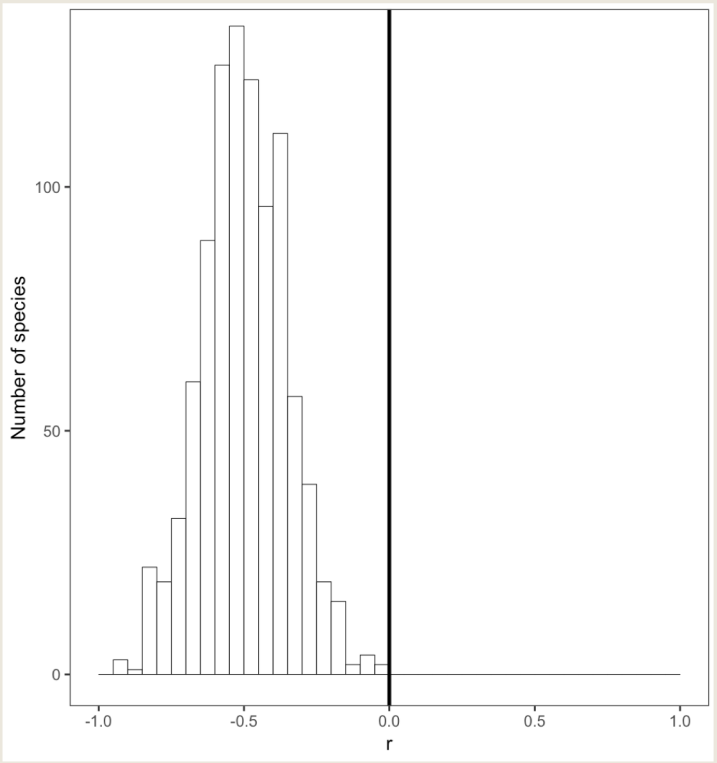
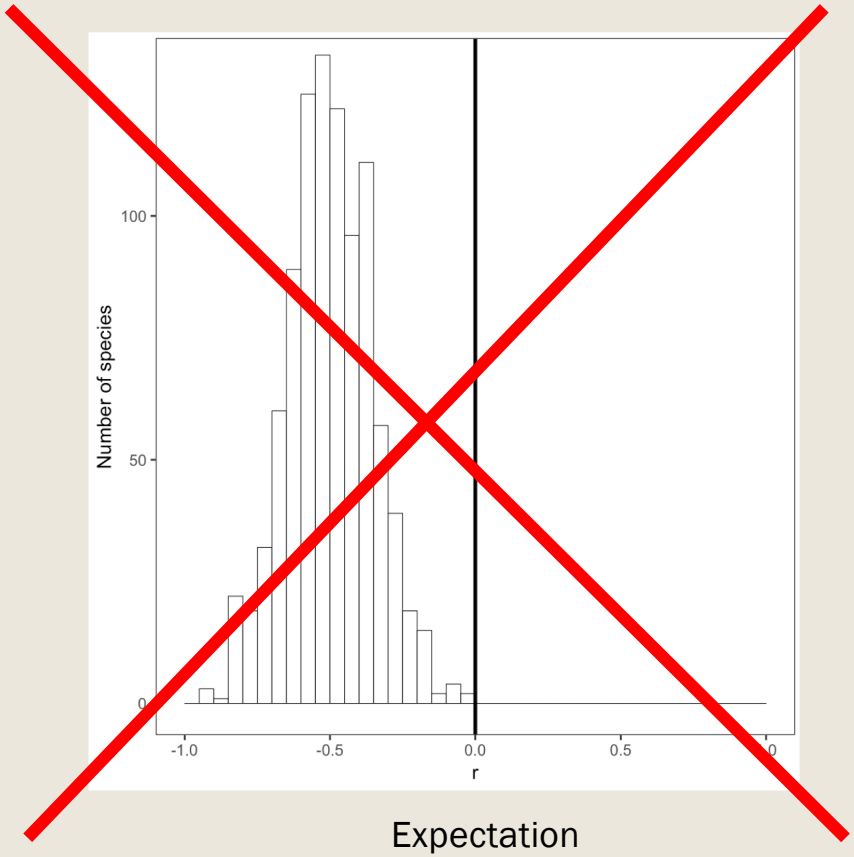
Lack of evidence for ecology “law”

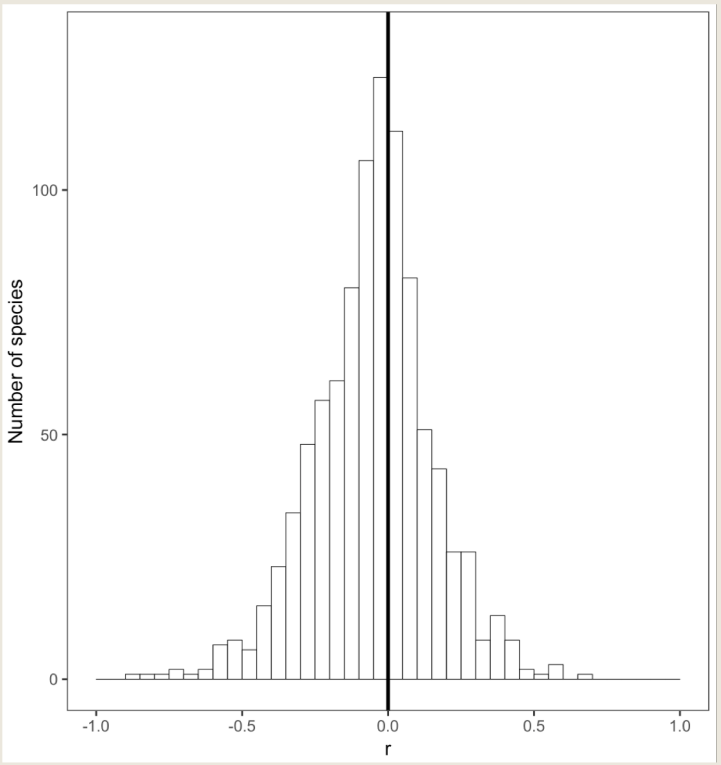


Expectation

Lack of evidence for ecology “law”



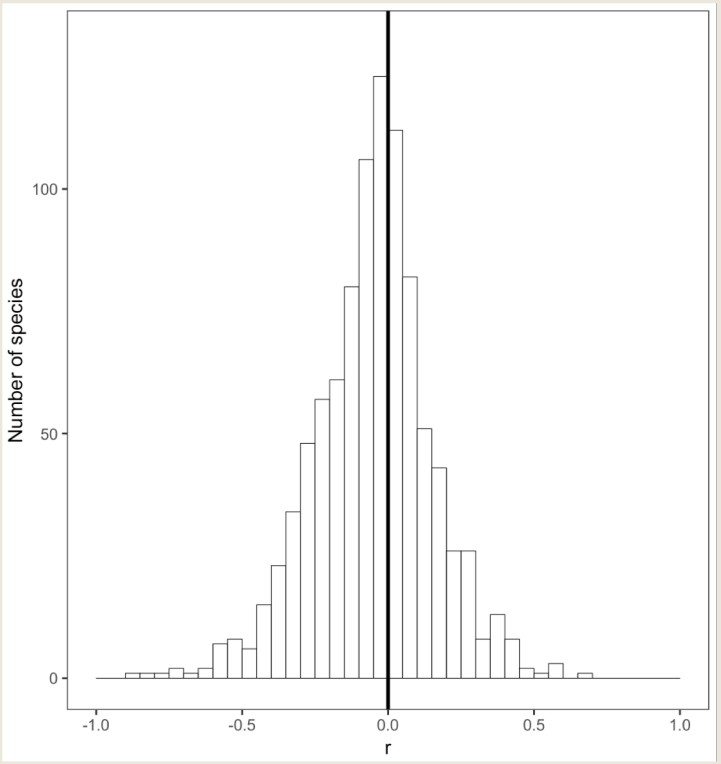
Expectation



Results from data-driven approach

Lack of evidence for ecology “law”

“These results suggest that Bergmann's rule is not general and temperature is not a dominant driver of biogeographic variation in mass.”

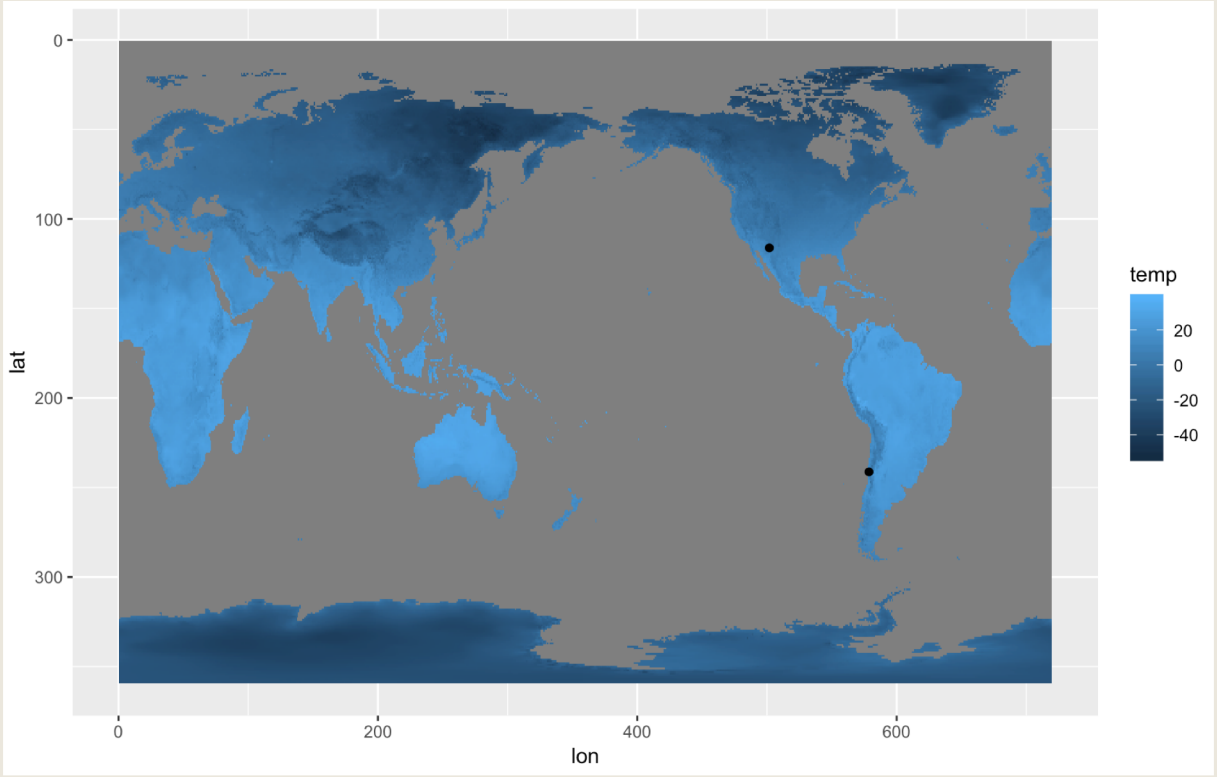


Results from data-driven approach

Best practices in scientific computing

- Understandable
- Reproducible
- Open

Current project



How mammals' sizes respond to temperature across time

Making this project more understandable…

- Modular code
- Good documentation
- Metadata
- Dynamic outputs

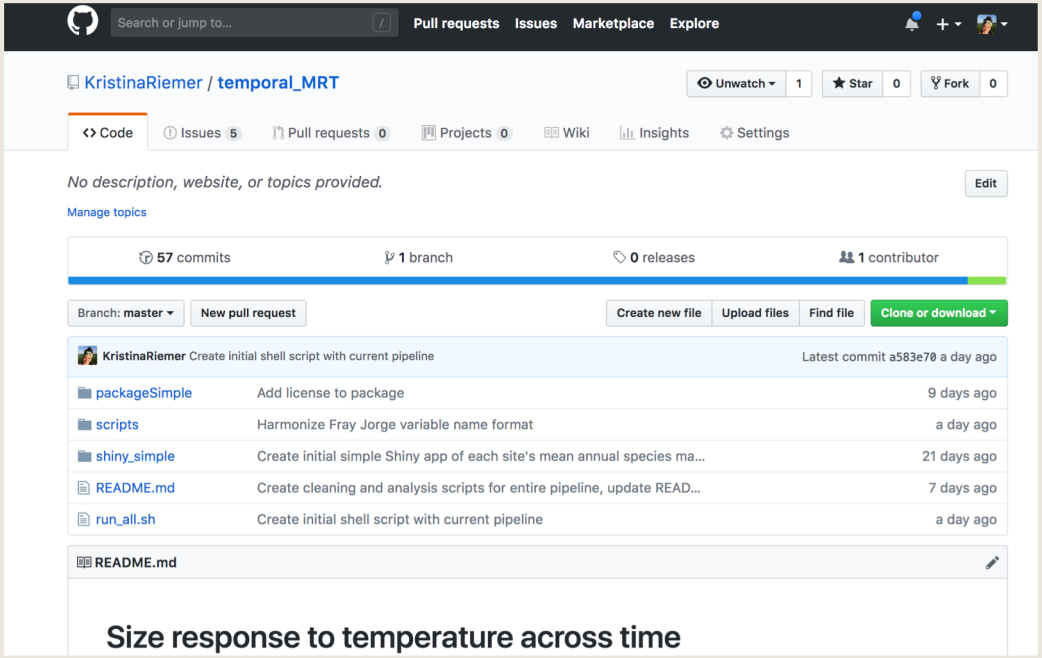
...more reproducible...

run_all.sh

```
#run entire project pipeline

#download and clean data
mkdir data
mkdir data/temperature
mkdir data/portal
mkdir data/portal/raw
mkdir data/portal/clean
mkdir data/frayjorge
mkdir data/frayjorge/raw
mkdir data/frayjorge/clean

Rscript scripts/cleaning/clean_portal.R
Rscript scripts/cleaning/clean_frayjorge.R
Rscript scripts/cleaning/combine_occurrences.R

Rscript scripts/cleaning/site_locations.Rmd
Rscript scripts/cleaning/site_temps.R
Rscript scripts/cleaning/species_temps.R

#run analyses and produce plots
mkdir plots
mkdir plots/portal
mkdir plots/frayjorge

Rscript scripts/analysis/main_fig.R
Rscript scripts/analysis/lin_reg.R
Rscript scripts/analysis/size_distributions.R
```

- Clear pipeline of inputs and outputs
- Complete description of this

...and more open!



- Publicly available data
- Real time tracking in public GitHub repo

So what's next?

- Testing and continuous integration
- Literate programming for manuscripts
- Documenting environments

Scientific software development

Understandable + reproducible + open = **reusable**

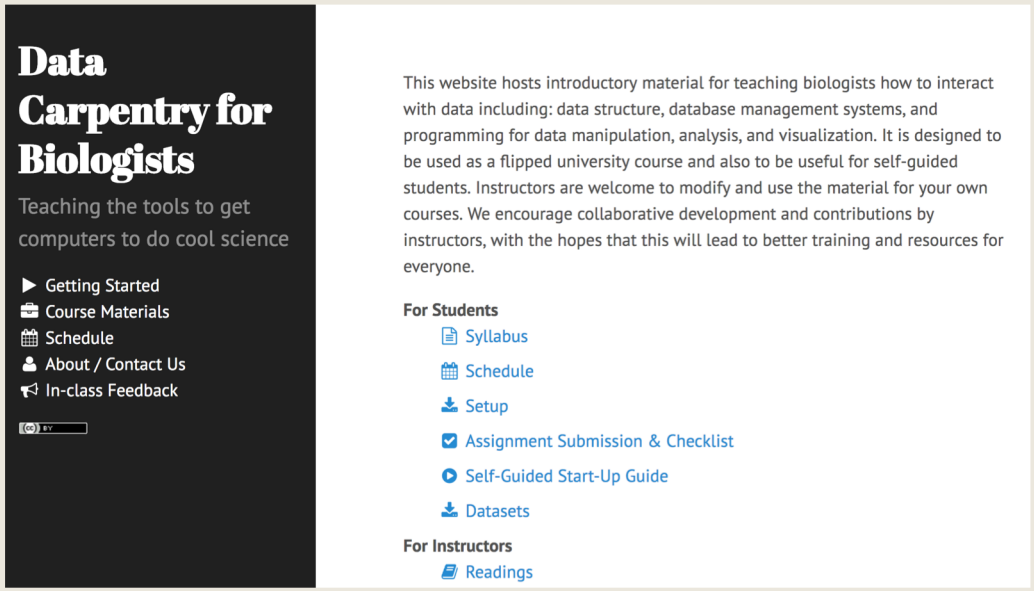
Motivation to train scientists

- Immense benefits for my own work
- Progress not perfection
- Researchers need these skills from good instructors and good materials

(More) motivation to train scientists

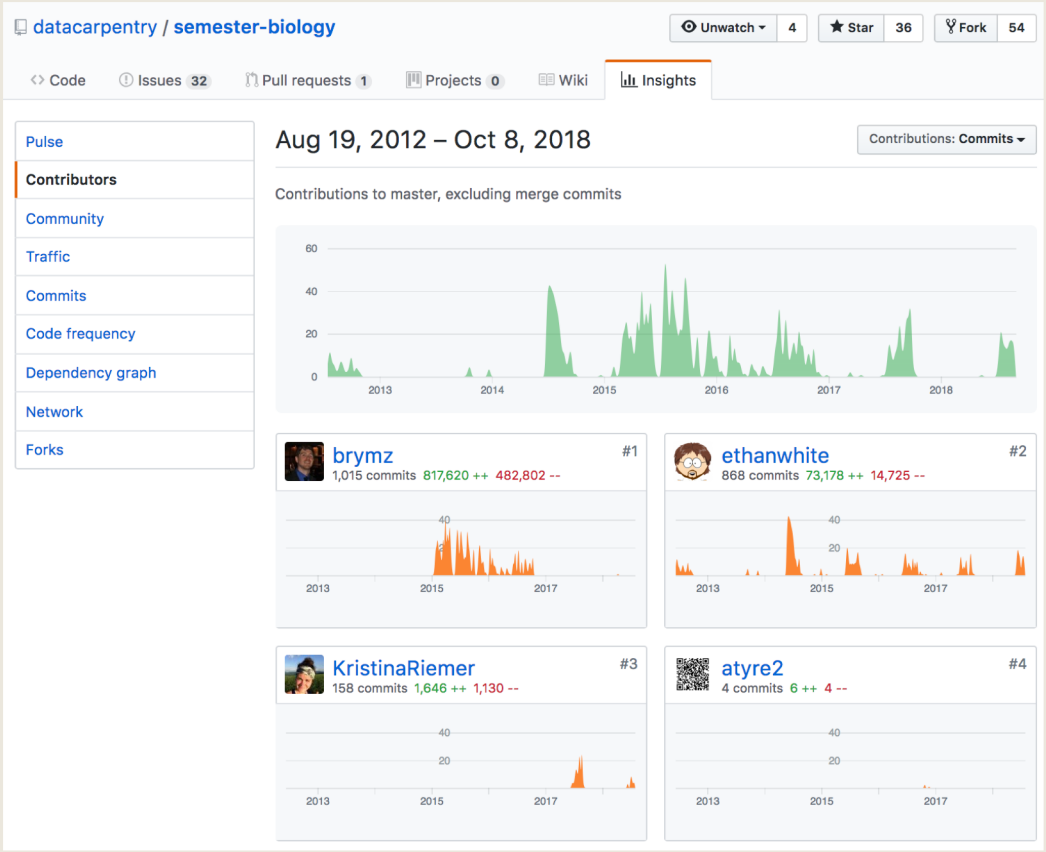
- Years being peer writing tutor
- Recently acquiring deep and broad computational skillset
- Really know it if I can teach it

Intro to computational skills course



- Instructor in fall 2017
- Databases, git, programming, project management, spatial data
- Really positive feedback from students

Open-source curriculum development



Additional curriculum development

- Initial hackathons for reproducible research workshop materials and geospatial workshop materials
- Official workshops for The Carpentries
  - See lessons on datacarpentry.org
- Teaching newest release of geospatial materials

What are The Carpentries?

- 2-day workshops
- Volunteer run

THE CARPENTRIES

Community building

- UF Carpentries Club
- Volunteer grad students and postdocs
- Fundraising, stakeholder needs, travel grants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Moments 0
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Media
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Hao Ye uses a flip phone @Hao_and_Y · 23h
The UF Open Source Club is hosting a in-person event fro #Hacktoberfest on October 20, from 10am - 6pm!
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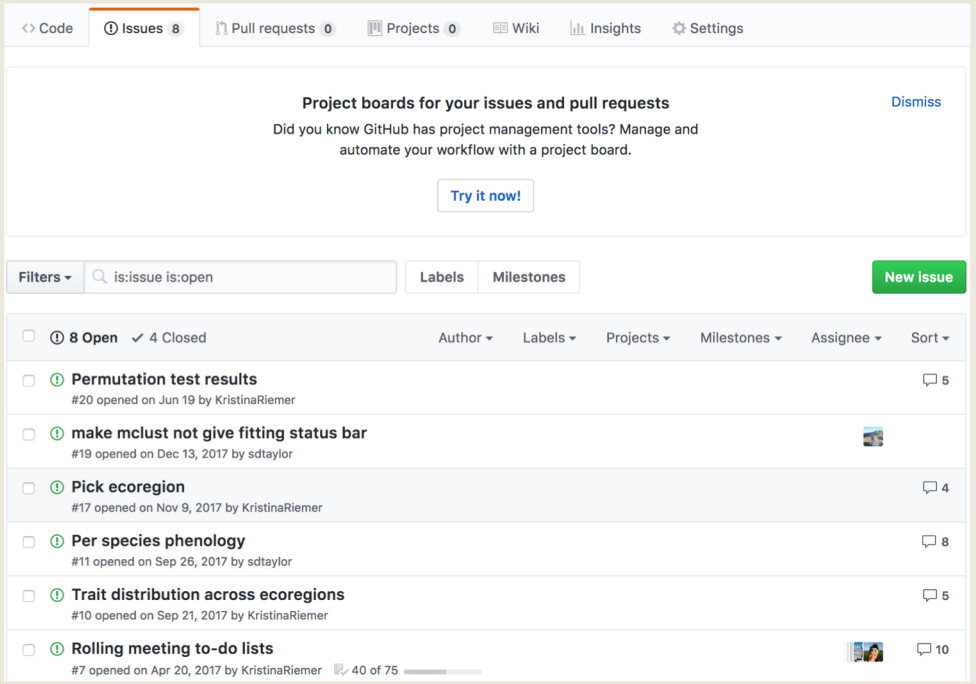
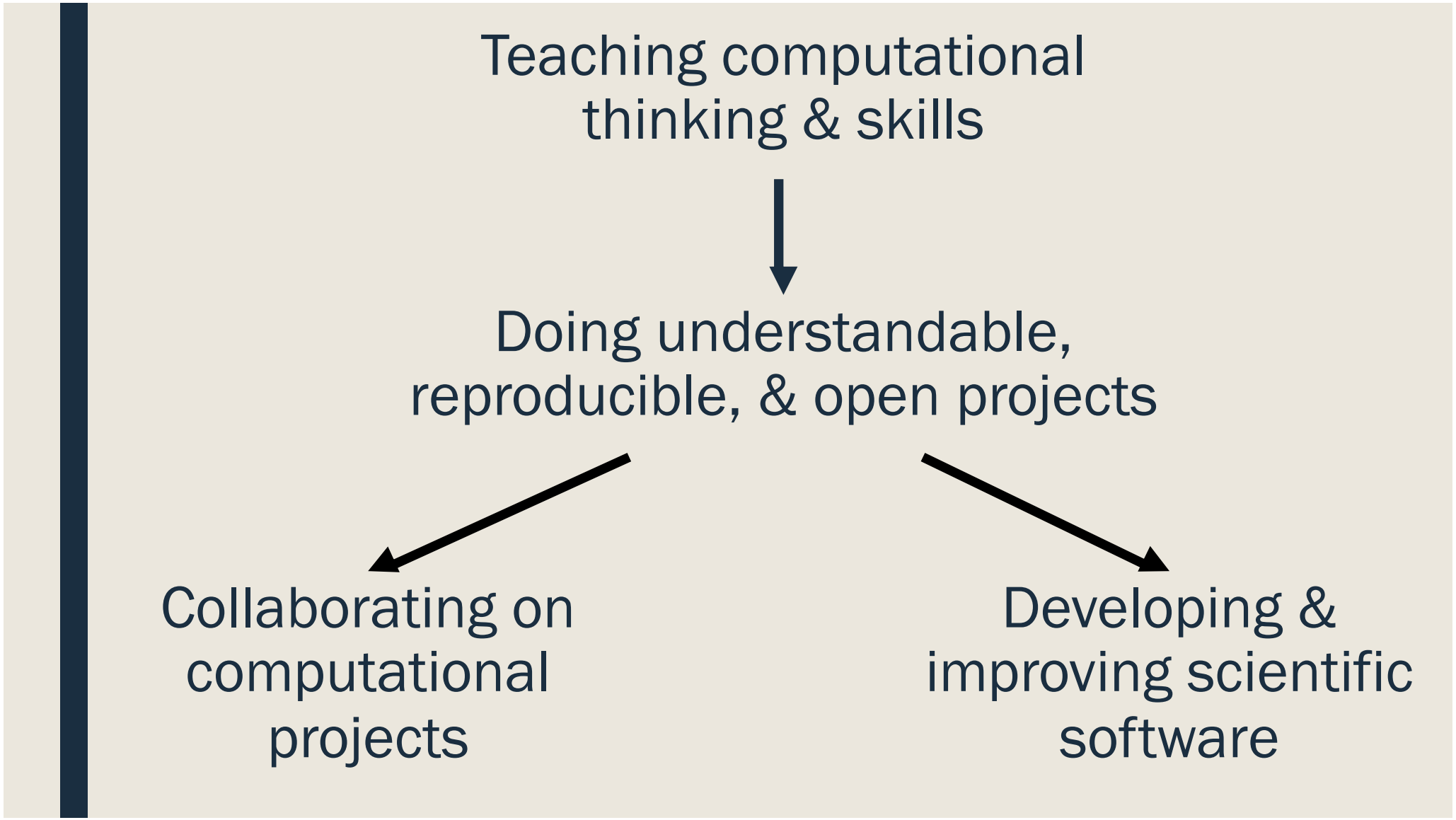
1
3
You Retweeted
Who to follow · Refresh · View all
Justin J Millar @justinjmillar
Follow
Joan Meiners @be…
Follow
Vanessa Hull @hull_wildlife

Communities enable good collaboration

- Lots of collaborative work
- Range of experience levels
- Remote work




Teaching computational thinking & skills
Doing understandable, reproducible, & open projects
Collaborating on computational projects
Developing & improving scientific software

Thanks for coming to my talk!

Feel free to contact me:

@KristinaRiemer

@KristinaRiemer

kristina.riemer@weecology.org

Acknowledgements

- Dr. Ethan White, PhD advisor
- Weecology lab members, including Dr. Morgan Ernest, Dr. Erica Christensen, and Joan Meiners
- UF Carpentries Club board members, past and present
- Special thanks to Dr. David LeBauer for the invitation to be here today

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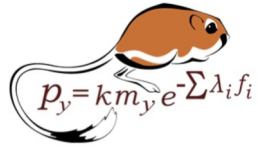
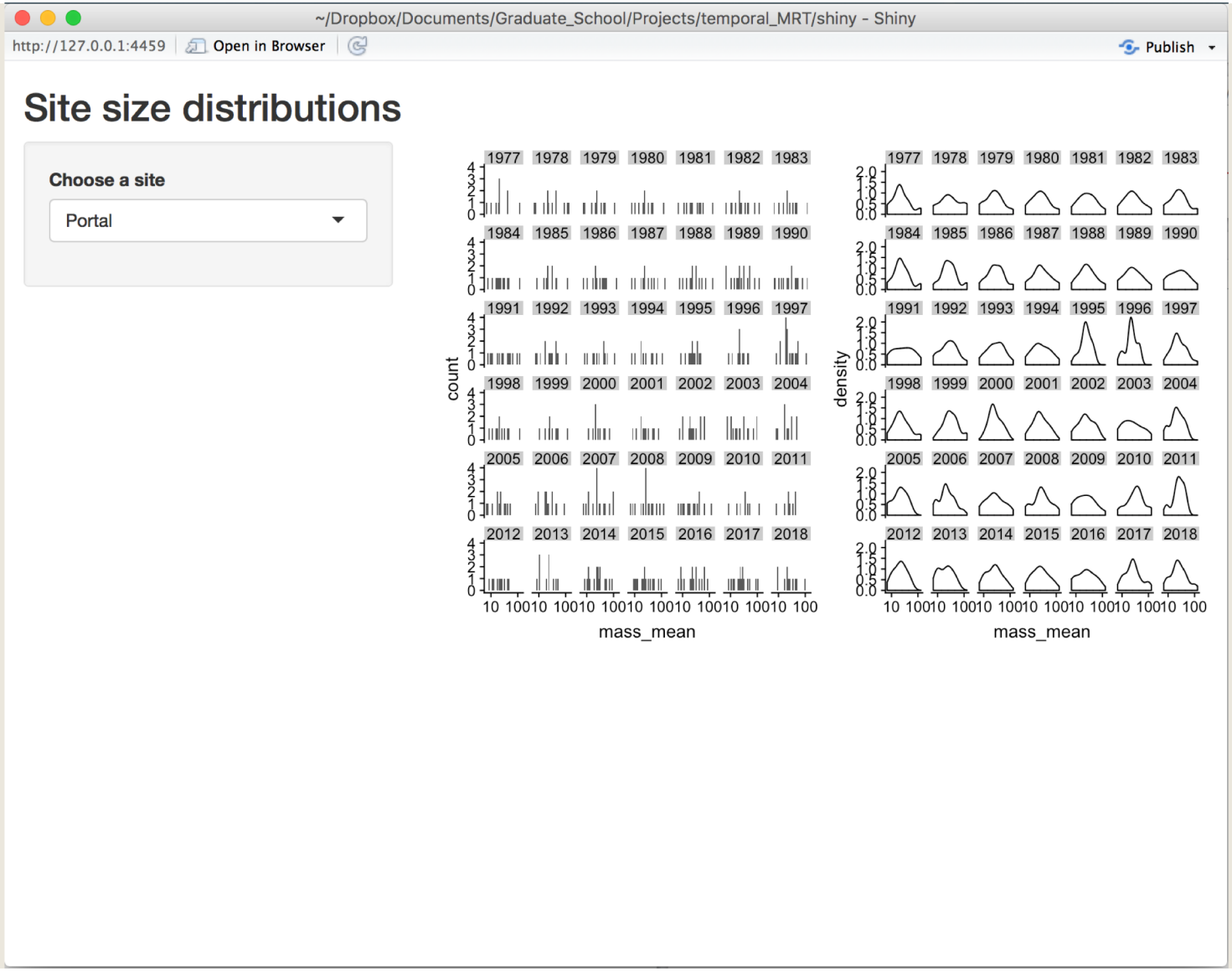
The Foundation for The Gator Nation

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Open in Browser
Publish
Site size distributions
Choose a site
Portal
count
density
mass_mean
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